RSVP Cost Review Report

P. Brindza, N. Hadley, P. Mantsch, M. Narain, G. Sanders, M. Swartz, G. Thomson, J. Yeck

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1 Introduction

On 20-21July 2000, a cost review of the RSVP proposal was conducted. The proposed RSVP (Rare Symmetry Violating Processes) program consists of two experiments to be performed at the Brookhaven National Laboratory (BNL).

The first experiment, called MECO (for Muon-Electron Conversion), would search for lepton flavor violation via the rare process $\mu^- N \rightarrow e^- N$. The conservation of lepton flavor is at least an approximate symmetry of the Minimal Standard Model (MSM). Although it is trivial to accommodate the violation of lepton flavor symmetry in the case of neutrino mixing and oscillation, the MSM predicts that the rate of muon to electron conversion should be immeasurably small. Many popular extensions of the MSM predict much larger conversion rates. The MECO proposal claims sensitivity to a (90% CL) level of 5×10^{-17} of the normal (weak) muon capture rate which would be sufficient to observe many of the MSM extensions. This program would therefore complement the program of direct searches for new physical processes that will be conducted at the LHC.

The second experiment, called KOPIO, is a search for the rare CP-violating process $K_L^0 \rightarrow \pi^0 \nu\nu$ (the MSM predicted branching ratio is 3×10^{-11}). This process, while extremely challenging to measure, is quite 'clean' theoretically. Unlike the other measurement of direct CP violation in the K-system, ε'/ε, the theoretical uncertainties associated with this process are small and the interpretation of a signal would be unambiguous. The KOPIO proposal claims to have sufficient sensitivity to measure the MSM predicted branching ratio with a relative precision of 0.15. The experiment also has unique sensitivity to various MSM extensions and thus complements the B-physics programs being carried out by the BaBar, BELLE, HERA-B, B-TeV, and LHCB Collaborations over the next decade.

The cost of the RSVP proposal was reviewed by a group of 8 panelists: P. Brindza (Thomas Jefferson National Laboratory), N. Hadley (University of Maryland), P. Mantsch (Fermi National Laboratory) M. Narain (Boston

University), G. Sanders (LIGO/California Institute of Technology), M. Swartz (Johns Hopkins University), G. Thomson (Rutgers University), and J. Yeck (Department of Energy). The costs of the two experiments were presented by their spokesmen: W. Molzon (MECO, University of California, Irvine) and M. Zeller (KOPIO, Yale University). There were also a number of proponents present: D. Bryman (KOPIO, TRIUMF/University of British Columbia), L. Littenberg (KOPIO, BNL), J. Sculli (MECO, New York University); and several representatives of BNL: T. Kirk (Associate Director for High Energy and Nuclear Physics, BNL), P. Pile (Collider-Accelerator Department, BNL). In addition to reviewing the cost of the RSVP proposal, the panel also commented upon the related issues of schedule, management, and manpower.

The recommendations of the panel are summarized in Section 2 and are discussed in more detail in Section 3.

2 Executive Summary

1. The panel was impressed by the quality of the material presented. A significant amount of careful detail has been generated in a relatively short time. The proponents were able to respond quickly to detailed questions.

2. We expect that the final project costs, after development of a resource loaded schedule and further refinement of the baseline definition, should be within 10% of the current estimate of $97 million in base year funds.

3. With further development of the estimate and definition of the project, the estimated contingency appears to be adequate.

4. Given the complexity and size of the projects, we find the three-year construction proposal to be aggressive. The panel recommends that both teams consider a five-year construction schedule. A detailed resource-loaded schedule should be developed as the next step.

5. The methodology currently employed is a good start on building an appropriate project plan. The committee urges the proponents to proceed to develop a definitive project baseline including cost and resource loaded schedule, and a performance measurement system, in preparation for a full baseline review next year.

6. The success of the RSVP program depends on project management consistent with the scope of the projects. It is vital that the project managers be chosen as soon as possible. Management tools should be developed including a project management plan, a more detailed work breakdown structure and a resource-loaded schedule. Of particular importance in the management plans is the definition of the relationship of the projects to Brookhaven National Laboratory.

7. The committee recommends that the roles and responsibilities of BNL be explicitly clarified. These include direct responsibility for improvements to the facilities and operations, responsibilities as an RSVP collaborator, and management oversight responsibilities as host laboratory.

8. It is important to fund the pre-construction R&D. The MECO experiment wishes to perform R&D on their solenoid design, beam development, and detection apparatus. The K0PI0

experiment wishes to perform R&D on their vacuum vessel, RF cavities, beam design, and detection apparatus. The proponents are encouraged to submit a proposal for this R&D. The panel feels that it is imperative for the work on the MECO solenoid to start immediately. The other R&D work should also begin as soon as possible because it is important for understanding the baseline costs and in developing the experimental collaborations.

9. **The review panel recognizes the MECO SC Magnet system as the single most important item considering cost, schedule and technical performance affecting the successful completion of the RSVP construction project. We therefore recommend the development and implementation of a magnet system management plan and acquisition plan ASAP and the completion in early FY 01 of the magnet system CDR. This will enhance the project cost baseline and lower the overall project risk assessment.**

10. **Both collaborations need to increase in size and should strongly consider issues of diversity as they expand.**

3 Detailed Report

3.1 Introduction

On the morning of July 20, the proponents presented their cost estimates in Work Breakdown Structures (WBS) of varying degrees of detail. WBS level 2 summaries are shown in Tables 1 and 2 for MECO and KOPIO, respectively. The total costs of the two experiments (including contingency) in FY00 dollars are $59.8 million (MECO) and $37.5 million (KOPIO), respectively. In general, an impressive amount of detail was presented for experiments that are still in the proposal stage and do not yet have detailed designs. The proponents had worked quite hard to accurately cost various components and had made considerable effort to be conservative in areas where there were uncertainties. The (conservative) formalism used by the US managers of the LHC experiments (ATLAS and CMS) to estimate contingency was adopted by both RSVP experiments.

The afternoon of July 20 was reserved for executive session and the preparation of questions for the proponents. A list of questions dealing principally with the cost of an extended schedule and possible scope contingencies was presented to the proponents late in the afternoon. The proponents responded on the morning of July 21. The panel then met in executive session to complete the discussion and to begin preparing this report.

MECO Cost Estimates Rollup

MECO Rollup						
Item		Summary Costs ($/1000)				
WBS code	Description	Base	Ind.	Cont.	Total	Cont. %
1	MECO	40361	5094	14326	59785	32
1.1	AGS modifications	1771	594	153	2517	6
1.2	Proton beamline	3322	1573	1409	6304	29
1.3	Prod. Tgt. and Shield	1241	80	282	1602	21
1.4	Solenoids	21222	266	7171	28659	33
1.5	Muon Beamline	1250	277	469	1997	31
1.6	Tracking Detector	774	227	270	1274	27
1.7	Electron Calorimeter	3403	129	1641	5172	46
1.8	Cosmic ray shield	2414	195	514	3124	20
1.9	Electronics House	338	108	71	517	16
1.10	Counting House	50	24	12	85	16
1.11	Electronics	2352	438	971	3760	35
1.12	DAQ and Online Comp	679	63	135	876	18
1.13	Project Management	837	411	776	2024	62
1.14	MECO-BNL Liaison	643	549	393	1586	33
1.15	RSVP Office	67	159	58	285	26

Table 1

KOPIO Revised Costs

WBS #	Description	Base Cost ($k)	Cont Cost ($k)	Cont %	Total Cost ($k)	EDIA Labor ($k)	Mfg Labor ($k)	EDIA Matls ($k)	Mfg Matls ($k)	FTE Project	FTE Other	Original - New	Comments
2	KOPIO	27518.39	6309.54	22.93	34199.26	2964.14	5126.68	0.00	19798.90	63.23	11.48	3307.74	without management reserve
2.1	Calorimeter	2975.45	600.03	20.17	3575.47	122.36	165.71	0.00	2687.38	2.80	0.36	834.87	
2.2	Preradiator	5981.22	1195.25	19.98	7176.47	91.77	538.06	0.00	5351.39	8.53	1.08	472.04	
2.3	Photon veto	3282.91	403.46	12.29	3686.37	28.80	144.00	0.00	3110.11	2.17	1.12	984.68	
2.4	Charged part. veto	418.89	68.33	16.31	487.22	28.80	33.41	0.00	356.68	0.81	0.00	129.54	
2.5	Catcher	1272.22	160.21	12.59	1432.43	43.20	68.09	0.00	1160.93	1.38	0.27	197.26	
2.6	Vacuum	1301.27	504.64	38.78	1805.91	37.72	241.41	0.00	1022.14	3.20	0.79	22.86	
2.7	Trigger	100.00	140.41	29.79	611.74	24.14	147.19	0.00	300.00	1.17	0.81	0.00	
2.8	Electronics infra.	133.83	17.69	13.22	151.52	0.00	133.83	0.00	0.00	1.44	0.79	630.29	
2.9	DAQ	497.37	72.65	14.61	570.02	137.96	60.46	0.00	298.95	1.64	3.25	36.20	
2.10	AGS mods.	3291.96	493.79	15.00	3785.75	1145.15	655.47	0.00	1491.34	11.37	0.00	0.00	
2.11	Beam	7014.35	2280.59	32.51	9294.94	1304.24	2167.68	0.00	3542.43	22.73	0.00	0.00	
2.12	Project Management	1248.93	372.48	29.82	1621.41	0.00	771.38	0.00	477.55	6.01	3.00	0.00	
	Magagement Reserve				3307.74								
	Detector	17212.08	3535.16	20.54	21118.56	514.75	2303.63	0.00	14765.13	29.13	11.48	3307.74	
	Detector*	17212.08	6842.89	39.76	21118.56	514.75	2303.63	0.00	14765.13	29.13	11.48	3307.74	*Mngmnt reserve added to contingenc
	Beam/AGS	10306.31	2774.38	26.92	13080.70	2449.39	2823.15	0.00	5033.77	34.10	0.00	0.00	
2	KOPIO total	27518.39	9617.27	34.95	37506.99	2964.14	5126.68	0.00	19798.90	63.23	11.48	0.00	

Table 2

3.2 Program Cost

RSVP presented a preliminary cost estimate of $97.3 million in FY2000 funds for a three year construction cycle. The estimate was reviewed at the summary level, and the methodology employed in generating the estimate was described by the project team. With the project team, the panel explored the sensitivity of the estimate to scope reductions, cost savings through reuse, and to a more credible 5-year construction cycle. The panel and team reviewed the risk analysis and contingency estimate. Our review was not a full study of the WBS at the lowest level as would be carried out in a project baseline review.

The estimate was prepared using a sound methodology, with attention to obtaining vendor estimates and to known costs for recent purchases. Bases for the estimates were clearly delineated. Conservative assumptions were made so as not to minimize or tilt estimates to lower costs. The Work Breakdown Structure (WBS) for each experiment is properly organized to emphasize deliverable products needed to produce RSVP

The WBS and estimate are a sound basis for further development of the estimate as the baseline design is firmed up. The collaboration properly stated its intention to continue development of the estimate in a bottom up manner. The WBS can be used to structure development of a project schedule. With both the estimate and the schedule based upon the WBS, the schedule can be resource loaded, providing the basis for a performance measurement system employing earned value.

As the cost estimate is refined, paralleling refinement of the technical baseline, some of the conservative assumptions used in the estimate can be "scrubbed" and any cost reductions resulting from this process can be added to the contingency pool. Some growth in costs may also result from further baseline definition. The entire RSVP cost estimate should also be carefully audited for uniform and consistent application of the methods by all estimators in all subsystems.

Scope reductions were identified by the proponents at the request of the panel. These promised only a few million dollars in cost reductions and they involved fixed choices required early in design definition. Thus, scope reduction does not appear to be an option for managing project risk during execution of the project if cost containment becomes urgent. An adequate contingency pool and disciplined design and construction to cost are the primary means of realizing the estimated cost during actual project execution. There are some opportunities for cost savings through reuse of existing materials. These are considered later in this report.

We expect that the final project costs, after development of a resource loaded schedule and further refinement of the baseline definition, should be within 10% of the current estimate of $97 million in base year funds.

3.3 Contingency

The line by line method used to estimate contingency funds is based upon the methods used in the US LHC detector projects, the Star detector for RHIC, the LIGO project and the SSC detector projects. This method, requiring a graded judgement of technical, cost and schedule risk for each estimated item has been employed by the RSVP proponents. They have also learned that the straightforward application of the algorithms should be tempered by expert judgement and they have been assessing and, in some cases, properly amending the results of the algorithm.

As the design evolves, and the estimates are refined, the team will have to balance conservative design choices with proper contingency planning so as to avoid "contingency upon contingency." The proponents do appear to understand this balance and plan to include it in their judgements in later refinements.

Opportunities for scope reductions and for selection of reduced cost options were discussed with the project team. Based upon this discussion, there are options for reductions in the direct cost estimate with increases in the contingency estimate. This demonstrates that as the estimate is made definitive, an adequate contingency pool should be available with the total estimate close to that presented at this review.

Thus, with further development of the estimate and definition of the project, the estimated contingency appears adequate.

3.4 Schedule

The proponents of MECO and KOPIO have each presented a preliminary narrative schedule for R&D and construction in their proposals. The presently proposed construction phase is of three-year duration. To realize the proposed schedule, most of the development and prototype evaluations need to be completed prior to FY02, the beginning of the construction phase.

In the panel's judgement, the MECO magnet will require a 5 year construction period. Given the complexity and size of the other elements of the RSVP project, we find the three-year construction proposal to be aggressive. There are significant elements of the program that can be accomplished within the three years proposed. The major subcontract placements and financial commitments and the corresponding funding profile likely fall within the three years proposed. However, fully completing the acceptance, installation and testing of several elements of RSVP will likely require 4 or 5 years. The panel recommends that both teams consider a construction schedule that extends to five-years.

The discussion of the schedule for both RSVP experiments in the proposal is at the summary level. A task by task schedule plan, based upon the WBS, has not been developed. Project scheduling infrastructure is not yet in place. We encourage both collaborations to promptly develop a detailed baseline schedule as the next step. This schedule should address all phases, such as development, prototype, construction, installation, and commissioning for all the subsystems of the detectors.

3.5 RSVP Baseline

The estimate reviewed by this panel addresses the RSVP project at the current conceptual level. Before construction begins, RSVP should develop a full cost, schedule and technical baseline and the NSF should review this baseline in order to place the project baseline under control.

The methodology currently employed is a good start on building a full project plan. The committee urges the proponents to proceed to develop a definitive project baseline including cost and resource loaded schedule, and a performance measurement system, in preparation for a full baseline review next year.

3.6 Project Management

The adequacy of the cost estimates presented by the proponents requires the discipline imposed by effective project management. Once selected, the project manager must assemble a project staff that should include a systems engineer, a cost and schedule officer, a quality assurance officer and safety officer. The systems engineer and the cost and schedule officer should be full-time positions. The other positions may be part-time. The project manager must be given full responsibility for building the detector as specified by the collaboration and sufficient resource authority to carry out this work. This authority should include approval over funds distributed to collaborating institutions.

The project manager will write the project management plan in cooperation with the spokesperson and collaboration leaders. The primary purpose of the project management plan is to identify the management structure with duties and responsibilities defined for each management level. The project management plan should also contain policy statements on design documents, technical reviews, reporting, configuration control, methodology for WBS and schedule, procurement practices, quality assurance and safety. Because of the importance of BNL resources to the projects, it is important that lines of responsibility and authority between the experiments and BNL be clearly defined.

The WBS and associated methodology presented by the proponents is an excellent beginning. This WBS needs to be expanded to more detailed levels of deliverables and the associated activities required to building the detectors. The activity levels of the WBS will form the basis of the project schedule. It is very important to have the organizational structure follow the WBS structure as closely as possible.

3.7 BNL Role

The committee recommends that the roles and responsibilities of BNL be explicitly clarified. These include direct responsibility for improvements to the AGS facilities and operations, responsibilities as an RSVP collaborator, and management oversight responsibilities as host laboratory.

Modifications to the AGS accelerator and experimental facilities and the accelerator operations R&D are collectively the largest cost element in the RSVP project. It is important that the BNL responsibilities for this work are defined at a detailed level so that the project, BNL, and the NSF have a clear understanding of the exact BNL resource requirements and deliverables.

It is understood that the responsibilities of each collaborating institution will be defined in MOUs. The BNL responsibilities as an RSVP collaborator should be addressed as part of this process.

In addition, NSF should charge BNL, as the host laboratory, with specific management oversight responsibilities for the RSVP experiments. The experiments require a management oversight role that is consistent with their significant scope, cost and complexity. A direct line of accountability for project performance should be strongly considered.

3.8 Preconstruction R&D

The two experiments described pre-construction R&D requests. Funding these requests is urgent. The proponents are encouraged to submit a proposal for this R&D.

In the case of the MECO experiment the longest lead-time item, which also is the item that drives the cost of the experiment, is the solenoid. Work on the design of the solenoid should begin as soon as possible. The proponents' plan to begin by preparing a conceptual design report is a sound one and should be started well before the MRE award would begin. This will require pre-construction R&D funds.

The MECO experimenters also wish to carry out R&D on the development of their beam and on the design of their detection apparatus. It is important to fund this work as well for two reasons. Carrying out this R&D will allow the experimenters to firm up their designs and allow them to make better cost estimates for these items. This will be very important in the process of making their baseline cost estimate and construction schedule. The second motivation is to strengthen their collaboration. The best way to weld together disparate institutions into a team is to assign each institution a definite hardware task, with funding attached. This will help them to recruit new collaborators as well. New collaborators are an urgent need.

The K0PI0 experimenters wish to perform R&D on their beam design, RF cavities, vacuum vessel, and detector apparatus. The largest individual cost in the experiment is their beam, and the beam cleanliness is a crucial parameter of the experiment. R&D should begin as soon as possible to verify that the design will work. The vacuum vessel and the RF cavities to bunch the proton beam are not items with large technical uncertainties, but pre-construction R&D is needed to firm up these designs. Although the detector apparatus is largely designed, R&D is needed to verify that these designs will really provide the efficiency and resolution that the experiment requires. At the time the baseline cost and schedule is made this R&D will be important to allow the experimenters to make accurate estimates.

Unlike MECO, K0PI0 does not have a single large item that drives the cost and schedule, and the K0PI0 collaboration has a nucleus that has previously worked together. However K0PI0 is a very challenging experiment and carrying out pre-construction R&D will be necessary for its success.

3.9 Solenoid Acquisition and Cost

The largest and possibly most uncertain cost estimate in the RSVP proposal is the one for the MECO superconducting solenoid system. Precise costing requires that the complex design and bidding process actually take place. The project WBS lists as item 1.4 Solenoid the following:

Base cost	$21222K
Indirect cost	$266K
Contingency	$7172K
Total cost	$28659K

This cost is in line with historical costs for similar magnet systems based upon a recent compilation (see M. Green et al.). Furthermore, the cost can be shown to be reasonable by scaling from similar systems using typical materials costs and nominal labor rates. Such cost comparisons and informal quotes from two well know manufacturers of super conducting magnets obtained by the National High Field Magnet Lab (NHMFL) establish some confidence that the final magnet system cost will be within 10 % of the above and that the 33 % level of contingency is adequate for this item.

The MECO project intends to invest in a Conceptual Design Report (CDR) using pre construction R&D funds in FY 01. The deliverable for this study will be a comprehensive CDR that will firmly establish the technical issues surrounding the magnet system, the costing based on a bottoms up WBS and sufficient drawings and analysis to form a basis for a Request For Proposal commercial procurement.

We strongly endorse this very necessary step and urge the NSF to make the necessary funds available in FY 01 to make this possible.

The solenoid system WBS must be expanded and detailed, preferably two levels below the presented material. The development of the expanded solenoid system WBS will be a necessary result of the solenoid system CDR.

Significant cost savings may accrue through the use of existing surplus materials (examples are listed below) and equipment available to the RSVP project. These items should be included in the WBS costing to further enhance the available contingency for this item.

Major Items Acquisition Plan

The RSVP panel recognizes the MECO super conducting magnet system as the critical item based on cost, schedule and technical performance that will affect the success of the RSVP project. A necessary part of a major acquisition totaling up to 28 M$ is a well conceived Major Item Acquisition Plan (MAP). The MAP should clearly establish the procurement strategy, the contracting office, identify the Contracting Officer (CO), the Contracting Officers Technical Representative (COTR), the acquisition schedule and a set of acquisition milestones. There should be an acquisition org chart that clearly establishes lines of communication between the MECO PI, The RSVP Project Manager and the Solenoid contracting office. Clearly there must be an established change control procedure that can regulate adjustments in scope, technical performance and cost and track the schedule. The MAP must demonstrate that the magnet acquisition will be managed by a procuring institution with the needed magnet and contract management experience.

The MECO magnet acquisition must be very well planned and staffed with experienced individuals accustomed to managing large technically complex contracts. NHMFL may be able to play this role with the appropriate relationship to RSVP. However, BNL has a special role as the receiver of the magnet. The MECO project team is encouraged to explore the role of BNL in the MAP with the aim of taking advantage of their considerable experience in handling large technically complex magnet projects. In the end, BNL will own and operate the MECO magnet. For this reason, BNL must either play a leading role in defining and producing the magnet, or be so intimately involved and able to influence the magnet evolution that they are able to smoothly assume ownership of a magnet produced by others.

The MAP must be close coupled to the proposed solenoid CDR contract especially as regards the inclusion of surplus material as Government Furnished Equipment (GFE). These cost saving items, delineated below, must be designed in for maximum effectiveness. The MAP must anticipate all the contractual issues that evolve from significant GFE and have plans and experience to deal with them.

Integration of existing surplus equipment

The review panel identified four items that have the potential to reduce RSVP costs significantly. The first two items relate to the superconducting magnet.

MECO	
Surplus SSC outer cable	$2 million
Surplus SSC/BNL Helium refrigerator	$3 million
Surplus shielding materials	$1 million
KOPIO	
Existing electronics	$3 million

The MECO and KOPIO teams are encouraged to investigate these items above and take fullest advantage. The MECO team would have to incorporate the requirement to use the SSC cable in the solenoid magnet CDR Statement of work.

It is further recommended that the MECO team investigate the following with BNL with the aim of further reducing cost and increasing contingency:

- A search of available power supplies at BNL that may be applicable to the Solenoid system.

- A cost benefit trade-off with BNL that compares a dedicated on site MECO Helium refrigerator fully staffed for the duration with a Helium transfer line to an existing BNL Helium refrigerator.

Solenoid Magnet system technical comments

The written material presented is excellent and reflects the current state of design work. The work of the NHMFL is also a well-done preliminary design document. The panel recommends some additions that will clarify and enhance the document.

The Solenoid system written material should include two tables that collect and clearly state the solenoid system requirements and the main technical properties of the current solenoid magnet design. The first table should include desired field strength, field gradients, size, length and bore, clear apertures, good field regions and field tolerances. The field tolerances are especially important, as these are substantial cost and technical drivers. The tolerances that are required for this experiment are not stated in the proposal. The field tolerances should be the result of a careful muon transport study to firmly establish these critical parameters. This information is very critical and must be available before the start of the solenoid system CDR. The GEANT simulations performed so far may be able to supply this vital information.

Figures 3, 4 and 5 in the report from the NHMFL displays very high design field tolerances. For example, field variations in the detector solenoid are displayed at the 10^{-4} level in the inset of figure 3. These field tolerances can be achieved.However the question regarding the actual required field tolerances for the MECO experiment is at present unanswered.

The second table should contain amp-turns required, operating current, turns configuration, coil configuration, proposed conductor dimensions, Cu:Sc ratio, operating to critical current ration, conductor current density, overall current density, energy margin, field margin, temperature margin, designed stability criteria, proposed method of coil constraint, stored energy, inductance, peak forces, designed tolerances, calculated weights of coil, cold mass, magnet and return iron if used, proposed cooling system and calculated heat loads.

The CDR design of the MECO solenoids should strive for a highly conservative and conventional design. The project budget and schedule cannot afford the time or cost of extensive development or prototyping. Furthermore the design, if sufficiently conservative, will attract highly qualified vendors at a reasonable cost. Finally a very conservative design will not require extensive factory testing and the acceptance tests can be performed at BNL at a substantial cost savings.

The present solenoid design seems to be based upon a segmented solenoid that uses small low-current sub-coils to shape the field. The 96 sub-coils are presumed to be potted. This design can be made to work if proper attention is paid to protection issues relating to the large stored energy and the high resulting inductance. The complex of sub-coil current leads and protection systems and the cryogenic costs of the large number of current leads should be considered. The DC and protection system and trim power supply system should be more carefully presented so that it is clear that power management issues and protection issues are completely thought out and that the considerable cryogenic complexity of 96 pairs of current leads or 96 persistent switches are considered. The present design has the flexibility that each sub-coil would have some degree of current adjustment albeit at the expense of a very complex DC system. Gaining full advantage of this flexibility and adjustment would certainly require an extensive magnet measurement program and a complex set of field trimming experiments. Finally the solenoid system controls would have to be able to adjust these currentsbased upon some field criteria that have not been specified as yet. This level of complexity may be justified but the field tolerance requirements have not been fully stated in a way that convinces the reviewers that this complexity is needed. The proposed system could be made to work when fully developed and all issues have been considered.

The Project should consider the several alternative design approaches toward realization of the solenoid system design during the CDR. The alternative approaches may result in a more robust or less costly solenoid. One such alternative is suggested here. A passively trimmed field at the accuracy required may be achieved simply by adjusting the turns count in each sub-coil by design alone. The use of a higher operating current cryogenically stable design suggests itself as a good match to the desirability for a simple low voltage discharge with excellent stability and the cold mass to safely handle the quite high stored energy. This type design would be easy to accomplish utilizing the surplus SSC conductor at substantial cost and schedule savings. The system would also benefit by having a much simpler DC and energy discharge system and a much simpler cryogenic system with perhaps 3 pairs of current leads instead of 96 lead pairs. Finally overall system control and operation would be much simpler.

Schedule

The MECO solenoid system will be, quite simply, the pacing item for the whole project. The CDR, acquisition phase, fabrication and installation and test will have duration extending over five years! The RSVP panel has suggested that the Project be optimized assuming one year of pre-construction R&D and five years from start of construction funding to experiment commissioning. The following sample schedule for the Solenoid system is offered to the project for consideration:

CDR Phase	9 months
RFP preparation & review	3 months

Year 1.00 Construction Funding Starts	
Bids	3 months
Initial technical evaluation	1 month
Competitive range determination Initial questions Vendor presentations	2 months
Request for final technical proposal DCAS audit	1 month
Final Evaluation	1 month
Request for best and final offer	0.5 month
Source selection	0.5 month
Contract negotiations and prep	1.0 month
Award approvals (NSF signoff)	1.0 month
Notice to proceed Year 2.00	

Magnet System Fabrication	
Program review and initial design	
	Year 2.25
mid term design	
	Year 2.50
Long lead time items ordered	
	Year 2.75
Final Design Review	
	Year 3.00
Tooling fabrication and test	
Trial winding	
Coil winding	
Sub coil tests	
Fabrication of cryostat components	
Controls design and fabrication	
DC system design and procurement	
Instrumentation design and procurement	
	Year 4.00
Production solenoid cold mass assembly	
Production solenoid cryostat assembly	
Production solenoid system assembly	
Transport solenoid cold mass assembly	
Transport solenoid cryostat assembly	
Transport solenoid system assembly	
Detector solenoid cold mass assembly	
Detector solenoid cryostat assembly	
Detector solenoid system assembly	
Ship and deliver	
	Year 5.00
Installation at BNL	
Initial cool down	
Commissioning	
Acceptance tests	
Ready for start of MECO	
	Year 6.00

Installation, system integration and test

MECO solenoid magnet system installation, system integration and testing at BNL is a substantial project by itself. The level of detail and coordination required for success on this item alone is quite substantial. This must be planned very carefully. Resources should be allocated early in the project with special attention paid to generating requirements for the CDR scope of work. The available space, floor loading, building access, site preparation, crane coverage, utilities and cryogenic services at BNL should be folded into the CDR scope of work so that the solenoid system is smoothly designed into the BNL fabric. It is essential that a knowledgeable BNL engineer or scientist be appointed as technical liaison to the MECO solenoid magnet system as soon as possible.

3.10 Manpower

Both collaborations need to increase in size in order to build the experiments on schedule and to operate them efficiently. The experimental teams in RSVP have little prior large project experience. Thus, additional collaborators and members with this experience are especially important in the planning stage. Project management and adequate technical and engineering support are urgent additions to RSVP.

As they expand, the collaborations should continue to strongly consider issues of education and diversity. They should also consider possible financial contributions from foreign institutions.

4 Conclusions

RSVP has developed a conceptual design and cost estimate that are an adequate basis for proceeding to development of a full technical, cost and schedule baseline. We expect that the final project costs, after development of a resource loaded schedule and further refinement of the baseline definition, should be within 10% of the current estimate of $97 million in base year funds.